STATION CARRIER APPLICATION

CONTENTS

1. GENERAL

1.1 This section is intended to provide REA borrowers, consulting engineers and other interested parties with technical information on the application of station carrier equipment. This application information provides guidelines on how to engineer and apply the equipment. Since there is some variety in the equipment such as number of channels per system, functional characteristics and packaging, this section must be supplemented by information from the individual manufacturers of station carrier equipment. For a technical discussion of

station carrier, refer to the companion TE&CM Section 912, "Station Carrier Equipment." Only equipment meeting the requirements of PE-62, "REA Specification for Station Carrier Equipment," (REA Bulletin 345-56) should be used.

1.2 There are two general categories of station carrier equipment--single channel and multichannel. The multichannel types are especially suitable for use in rural telephone systems. The single channel systems are not repeatered and are generally installed within 18 kilofeet of the central office. Most of these guidelines refer to the multichannel station carrier application. In practice, the two types should be considered together, using the inexpensive single channel types closer in to the office where wire pairs are more readily available and the multichannel types to derive four or more separate lines over one wire pair. Systems supplied by different manufacturers can be used in the same cables.

2. EQUIPMENT CHARACTERISTICS

2.1 For details on the characteristics of station carrier refer to TE&CM 912 and REA Specification PE-62. A brief summary of the characteristics follows:

a. No installation adjustments (minor exception)
b. No periodic maintenance
c. Low loss circuit (2 to 4 dB)
d. Low noise circuit (0 to 20 dBrnc)
e. Excellent return loss
f. Excellent signaling capability
g. Can be applied up to 2400 ohm cable loop or 140 dB (at 112 kHz) loop without special engineering considerations

2.2 Station carrier is designed so that it can be used as "movable telephone plant." This is accomplished by eliminating the need for installation adjustments. When the equipment is engineered and installed within its specified limits, all transmission and signaling requirements are automatically met. This includes manufacturing tolerances and the "worst case" voice frequency drop beyond the subscriber terminal. Station carrier is compatible with present types of central offices of all loop lengths without adding loop extenders, booster battery, voice frequency repeaters, etc.

3. STATION CARRIER USES

3.1 The use of station carrier should be considered as an economic alternative to cable plant (especially additions) in most circumstances. Its use should be considered when:

a. Upgrading - Station carrier is especially attractive if the entire exchange can be upgraded without adding cable.

b. Installing new cable - Compare the cost of station carrier and fewer cable pairs versus using much larger cables.

c. Growth areas are uncertain - Supply the intermediate needs by using station carrier.

d. Held orders - Can be filled without long delays until cable pairs are available.

e. Temporary service needs - Can be supplied without delay.

In circumstances on routes where cable pairs are not available and additional circuits are needed (such as c, d and e above), station carrier can provide these needs without delay. This allows some additional time to survey the cable needs more accurately. When new cable is installed on a route, the station carrier can be removed and used in another location. Some telephone companies have adopted this concept of "movable telephone plant" instead of installing large amounts of cable long before it is actually needed.

3.2 Station carrier can be planned for future service needs. Cable pair sizes can be based more on current and near future requirements and station carrier can supply future service needs. Station carrier should especially be considered where growth requirements are uncertain. Planning future use of station carrier in this manner avoids the necessity of having a large number of idle pairs for an extended period of time. (Example: If the present requirements of a cable route are for 23 pairs, a 37 or 50 pair cable would normally be used. If future needs are uncertain, a 25 pair cable may be used; station carrier could then be used when the growth occurs.)

3.3 Several rules of thumb have been tried to quickly determine if station carrier proves in over a physical design. With the varying cost of station carrier and cable, the only real way to obtain a valid comparison is to make a detailed study for each application. Most economic studies consider first cost investment and annual cost comparisons. If there is an emergency demand for additional circuits over a cable that is already full, station carrier usually proves in for such an emergency (if enough cable pairs are available). On planned large scale applications such as upgrading and multiparty service to single party service, station carrier may prove in on rural systems where the existing plant can be retained and little or no outside plant additions are required. The initial and annual costs will serve as guidelines in the selection of the design. In general, the design with the lowest annual cost should be selected although other considerations such as shortage of capital, quality of transmission of long subscriber loops and flexibility of having movable plant should be considered. REA

recommends that on station carrier annual cost studies a depreciation rate of five percent (20 year life) and a $15 annual maintenance cost per channel be used (refer to REA TE&CM 218, "Plant Annual Cost Data for System Design Purposes).

3.31 Station carrier will rarely prove to be economical in areas close to the central office except where only a few circuits are needed. There is no "fixed" prove-in distance for station carrier. A good starting point for economical use of station carrier is the distance where loading is required, 18 kilofeet. It is recommended that a route-by-route comparison of physical versus carrier be made where a reasonable quantity of the loops exceed 18 kilofeet. Some cost comparison examples are shown in Appendix 1.

4. ENGINEERING STATION CARRIER ROUTES

4.1 Facilities: Station carrier is designed to be used primarily on 19, 22 and 24 gauge cable, buried or aerial. Incidental lengths of 26 or 16 gauge shielded wire or cable can be used. Buried wire meeting requirements similar to cable can be used (i.e., shielded facilities). Station carrier applied to open wire and RDW has met with varying degrees of success. Except as a temporary measure, it is recommended that RDW and open wire not be used as a carrier frequency facility for station carrier. Short lengths of open wire and RDW may be used as voice frequency drops from the subscriber terminal if it is already installed and costly to replace. Refer to Tables 1 and 2 for wire and cable data on attenuation and resistance.

4.11 Equipment containing compandors and meeting the requirements of PE-62 can be used on up to 100 percent of cable pairs meeting REA cable crosstalk requirements. The inexpensive single channel types which do not contain compandors or automatic level coordination can be engineered on a "large percentage" of pairs. Experience may show that occasionally this type might have to be replaced with the more costly types of single channel or multichannel station carrier.

4.12 Station carrier routes should be engineered with repeaters spaced at intervals of 35 dB (at 112 kHz) and with channels located within 35 dB (at 112 kHz) of the central office terminal or repeater location. The exact location of repeaters is generally not critical on short systems (one or two repeaters). On longer systems repeater spacing must be observed closer. Most of the engineering guidelines in paragraphs 4.1 through 4.8 refer to the multichannel type of station carrier. The physical pair is used for supplying power to repeaters and subscriber terminals of multichannel types; for this reason the physical pair cannot generally be used as a voice frequency subscriber circuit. These guidelines briefly cover the engineering of single

channel types also (see paragraph 5.8 for more application details on single channel systems). Figure 1 gives an explanation of the symbols used.

4.2 Repeater Location: Repeater location should be determined by computing 35 dB sections (at 112 kHz), beginning at the central office. The repeater location should be a convenient location near the computed location. While some types of station carrier repeaters may provide good operation between 20 to 40 dB loss (i.e., 2.2 to 4.5 miles of 22 gauge cable), this large variation should be avoided for economic and technical reasons. After the repeater locations are selected, an insertion loss measurement at 112 kHz should be made on up to 3 pairs in each section of cable (see paragraph 6.2). The purpose of this measurement is to verify that the actual cable is approximately the same length and gauge as shown on the plant records. Since the repeaters are self-regulating, measurements on each pair are generally not necessary. Major faults that cannot be overcome by the automatic regulation will usually be apparent and inoperative equipment readily located.

4.21 Do not stagger repeater locations. The repeaters on each route should all be at common locations to avoid crosstalk resulting from level differences. Several different types of station carrier can be used on the same route provided the repeaters are at common locations. Figure 2 shows the correct and incorrect location of repeaters. Where some systems are repeatered and others are not, repeaters must be in all systems that go beyond the repeater point if all are in the same cable beyond the repeater point. The subscriber terminals may be located at distances greater than 35 dB in the same cable with repeatered systems if the cable sections beyond the repeaters are not common for repeatered and nonrepeatered systems (see Figure 3). The objective of these recommendations is to maintain carrier level coordination. (These coordination recommendations apply to the nonrepeatered one channel types also.)

4.22 Where it is inconvenient to locate repeaters at 35 dB, the spacing can generally be 30 to 40 dB. For systems containing several re-repeaters, the average spacing should be near 35 dB. Where one section is long (i.e., 40 dB), the next section should be shorter than 35 dB (see Figure 4). As the system length increases, the need to maintain 35 dB spacing also increases. This is because the repeater regulation and attenuation slope is fully automatic; thus attenuation slope variations add up on longer systems.

4.3 Extended Length Systems: Station carrier was designed to be capable of serving more than 95 percent of the subscribers in a "typical" rural exchange. Most exchanges contain a small number of loops beyond the

"normal" range of station carrier. For some rural exchanges in sparsely settled areas, a large number of loops may exceed this "normal" range. Special engineering consideration must be given to these long loops. Below are some general application guidelines for extended length systems. If the system length exceeds 140 dB at 112 kHz or the powering limits specified by the manufacturer, consult each manufacturer for specific application instructions for their systems.

4.31 For systems using four or five repeaters the standard attentuation slope networks in the repeaters should be sufficient. Try to maintain near 35 dB spacing of repeaters. For systems longer than five repeaters, repeaters may have to be "special." These "special" repeaters may need an attenuation slope network to match the cable gauge(s). This is done to maintain uniform carrier levels and improve noise and crosstalk characteristics. The carrier frequency filters may also need improvement in "special" repeaters. All manufacturers may not recommend that their equipment be used for extended length systems. See paragraph 4.81 on supplying power to these long systems.

4.32 Where extended length systems are proposed, consider using coarser gauge cable in lieu of more repeaters if the cable is not already in place. Expecially consider coarser gauge cable where the number of pairs is small or the cable route contains a large amount of station carrier.

4.4 <u>Subscriber Terminal Location</u>: In general, the subscriber terminals should be located along the carrier system main cable route; the terminal location should be as close to the subscriber(s) it serves as is conveniently possible.

4.41 The most common packaging of subscriber terminals is one channel per housing. Other variations include two channels per housing and one or many systems of subscriber terminals in a housing. These are designed for outside mounting. (There is one multichannel system and many single channel systems where the subscriber terminals are mounted inside the subscribers' buildings served by the carrier.)

4.42 The voice frequency drop loop limit for multichannel station carrier is usually 200 to 300 ohms (dc resistance) between the subscriber terminal and subscriber's telephone set. For one party service and most multiparty service, subscribers can be clustered within the required limits without difficulty. The voice frequency drop loop limit for station carrier mounted in subscribers' buildings is usually 25 ohms.

4.5 <u>Bridge Taps</u>: The engineer must rely on the specific rules of each station carrier manufacturer concerning bridge taps. The following guidelines should serve as a general basis for engineering

the infrequent bridge taps for multichannel systems where subscriber terminals are mounted outdoors. The multichannel types of station carrier with subscriber terminals mounted inside buildings require special consideration since there will generally be a bridge tap from the main line for each subscriber terminal. Refer to the manufacturer's instructions for all guidelines for these types.

4.51 Low subscriber density sometimes requires that the carrier frequency line contain bridge taps. Carrier bridge taps can be used where the carrier route must divide for economical reasons or if the distance from the carrier route to the subscriber exceeds the drop limits of the equipment. If the tap must occur between repeaters, a line splitter must be used. There should be no more than one bridge tap between the central office and the last repeater to maintain good carrier levels. If a tap occurs after the last repeater, using a line splitter is optional. If there is more than one bridge tap beyond the last repeater, a line splitter should be used for each tap. Termination units (TU) must be used at the end of all taps as well as the main line. See Figure 5 for examples of bridge taps. (Paragraph 5.6 discusses bridge taps further.)

4.6 Single Channel Types: Single channel station carrier systems are simple in design and easy to engineer and install. In general their use is limited to 35 or 40 dB (at 112 kHz) or 18 kilofeet or within the first repeater section if repeatered systems are in the same cable. These systems are applied as a second subscriber circuit to a physical subscriber's line. See paragraph 5.8 for more application details on single channel systems.

4.61 Where the above limitations can be met, the single channel systems can be used to double the available circuits near the central office without detailed engineering. Below are some general guidelines for engineering these systems beyond the above limitations. (The manufacturer should verify these guidelines.)

4.62 If the physical circuit extends beyond 18 kilofeet, it must be loaded or otherwise improved over nonloaded circuits. A means of bypassing carrier frequencies around loading coils is one way to extend the voice frequency and carrier circuit. Guidelines for such applications are not included in this section. Some manufacturers state their equipment can operate up to 43 dB loss at the highest carrier frequency. If the single channel types can be placed in a separate binder group from repeatered systems (in larger cables), the nonrepeatered systems can probably be used beyond the first repeater location without crosstalk problems.

4.7 Pair Requirements: Pair requirements for mixes of station carrier and physicals must be determined. Presently there are 4, 5 and 6

channel systems per wire pair plus the add-on single channel types. For the sake of discussion, a 6 channel system will be used in the examples.

4.71 Figure 6 shows an example of the pair requirements to upgrade a rural cable route using station carrier. This pair determination must be made for the main route, bridge taps and for voice frequency drops from the subscriber terminals.

4.8 Power Requirements: Station carrier systems generally receive all power from the central office battery. When computing central office battery requirements, allow for the current required by the station carrier.

4.81 Where a large number of subscriber terminals are at the same location, the manufacturer may offer options to use local ac power. This arrangement should include standby battery for eight hours of normal use. Where the systems extend beyond the manufacturer's normal powering range (extended length systems), intermediate power must be provided at a convenient location. This will require field mounted power supplies with standby battery. Figure 7 shows an example of powering long systems. The power should be applied at points where the maximum number of systems can be powered from the same supply (and standby battery). The manufacturers may have to provide special engineering for these systems.

5. EQUIPMENT APPLICATION AND INSTALLATION

5.1 General: Methods and techniques of installing station carrier equipment are covered in paragraphs 5.2 through 5.8. The equipment primarily covered is multichannel station carrier; the single channel equipment is briefly covered in paragraph 5.8.

5.2 Equipment in Central Office: Most central office terminals of station carrier are self-contained packages of all equipment needed at the central office to put a system into service. The installation of these systems includes the following. The central office terminal is mounted in a rack and connections are made to -48 volts dc, ground, alarms and from the carrier frequency terminals to the cable pair on the equipment side of the MDF. Each channel voice frequency drop is assigned to the COE as if each were an individual cable pair. When space in the central office building is assigned for station carrier equipment, allow enough space for present and future requirements.

5.21 Some central office terminals are designed for use with common equipment. A power supply may serve several systems to power the central office terminals and/or to power the repeatered lines. One type uses a special ringing system; this ringing supply consists of voice frequency tone that is connected in series with the central office ringing generator. One supply is needed for each central office.

5.3 Repeaters: The repeaters are usually packaged with each repeater in a separate housing. Another common packaging is two repeaters per housing. Where several repeaters are located at one point (usually the first repeater from the office), multiple unit housings are used to improve the appearance of the installation. Generally each repeater has five electrical connections to be made--tip and ring toward the central office, tip and ring toward the far end and ground. The cable pair is opened at the repeater point and the repeater inserted between the two ends. Most repeaters use terminals to make the wire connections. One type contains a cable stub and can be direct buried if necessary.

5.4 Termination Units: A termination unit (TU) is used at the end of each carrier frequency line. This TU terminates the carrier frequency line in its characteristic impedance. This must be done where subscriber terminals are distributed along a line to avoid transmission problems. The TU is generally a resistor (i.e., 110 ohms) in series with a capacitor and protected with a gas tube with two leads to connect to the cable pair. (The TU may be a strapping option inside the subscriber terminal.)

5.5 Subscriber Terminals: The subscriber terminals are usually packaged with one subscriber terminal channel per housing. Other variations include two channels per housing and one or many systems of subscriber terminals in a housing. These are designed for outside mounting. There is one system available where each subscriber terminal is mounted in the residence it serves. Most subscriber terminals are designed to bridge on the carrier frequency line. The wire connections consist of carrier frequency tip and ring, voice frequency tip and ring and ground. There may be other connections necessary between the subscriber terminal and telephone sets, such as a separate wire for the ringer and extra wires for two party ANI. One type of station carrier uses a constant current equipment powering arrangement. This subscriber terminal must be inserted into the carrier frequency line like a repeater.

5.51 Depending on the type of equipment used, the voice frequency drop can extend up to 300 ohms of dc loop resistance from the subscriber terminal. This 300 ohms should be sufficient to distribute multiparty subscribers without difficulty. While some types could utilize drops longer than 300 ohms, this limit is a good practical value. At 300 ohms or less, transmission requirements can always be met without consideration of loading the drop or adjusting the net loss. (With 19 gauge, 300 ohms is about 18 kilofeet.)

5.52 The subscriber terminals are generally located at the main cable route, with a voice frequency cable pair connecting the subscribers. One way to view this voice frequency drop is to compare the overall circuit to a voice frequency circuit over loaded cable. The ground rules on loaded circuits are to connect all subscribers after the last loading coil.

(This is called "end section.") With station carrier the subscribers can be connected within the drop limits of the subscriber terminal. This is up to 18 kilofeet or the resistance limit of the subscriber terminal. When one party service is supplied, this drop is generally very short, resulting in very good transmission characteristics.

5.6 Bridge Taps: Bridge taps in the carrier frequency lines are used when the distance from the carrier line to the subscriber's residence exceeds the equipment drop limits (outside mounted subscriber terminals). Figure 5A shows an example of this where the subscribers served by channel 4 and 5 exceed the drop limit. The carrier frequency line may be joined (bridged) or may be connected through a line splitter. The additional loss caused by the bridge tap is 3 to 4 dB with or without the line splitter. If the bridge tap is between repeaters, the line splitter should be used to maintain a good impedance match for the repeater (see Figures 5B and 5C). A TU must be used to terminate both taps.

5.7 Inside Mounted Equipment: One type of multichannel station carrier is mounted inside subscribers' buildings. Follow the manufacturer's instructions for installation of equipment and treatment of bridge taps on the carrier line.

5.71 One type of station carrier uses a tone detector in the subscriber's building to provide ringing (selective or single party). The voice frequency drop extends from the carrier subscriber terminal on a two wire basis. The tone detector bridges the red and green station wires (tip and ring) in the building; a separate yellow lead extends from the tone detector to the telephone set yellow lead to supply ringing for a straight line ringer.

5.72 Several types of station carrier provide a nominal 20 hertz ringing signal for the subscriber's telephone set. Straight line ringers must be used since the nominal 20 hertz may not be stable enough for frequency selective ringers. Some equipment can provide key system operation (refer to manufacturer's information).

5.73 Some equipment located in subscribers' buildings may need local ac power. This includes some subscriber terminals, key system interface, etc. The most popular arrangement of supplying this power is to use a small low voltage transformer (similar to a doorbell transformer). The low voltage ac can then be distributed with inside wiring. Devices using local ac power must be listed by Underwriters Laboratories, Inc.

5.8 Single Channel Systems: Installation of most single channel systems consists of the following (see Figure 8). The central office terminal of the carrier equipment is connected to central office

line circuits as if there were two physical lines. The carrier line terminals are connected to the outside plant at the MDF. The physical subscriber is connected to the main cable through a low pass filter. The cable pair extends to the carrier subscriber's building. Inside the carrier subscriber's building the station carrier line terminals connect to the outsdie plant (through station wiring). The red, green and yellow lead of the telephone set connect to the station carrier. (The yellow lead is generally separated from the red and green.) Generally a straight line ringer is required in the telephone set.

5.81 There are other installation and application variations of single channel systems. These include party line service on the physical circuit, use of ac power in the subscriber's building, key system application and perhaps others. There may be outside mounted single channel equipment available in the future. Information on these variations will have to be obtained from manufacturers.

6. ACCEPTANCE TESTS

6.1 The recommended acceptance tests for station carrier are outlined in REA Standard PC-4, "Acceptance Tests and Measurements of Telephone Plant." These tests are required when station carrier is installed under a 511 Contract and are recommended at other times also. The tests consist of insertion loss measurements on facilities and operational tests of equipment.

6.2 Insertion loss measurements should be made on up to 3 pairs (assigned for carrier use) on each repeater section of each cable route. This provides a record of insertion loss for comparison in future years. It also serves to assure that the repeater location is correct. Generally, it is not necessary to measure all pairs.

6.3 Preinstallation tests consist of a "burn-in" of the equipment for at least 8 hours. Operational tests (talking, listening, ringing and dialing) are then made to verify that the equipment is functioning properly.

6.4 After the equipment is installed, operational tests are again made from each subscriber location. From the talking, listening, dialing and ringing tests the engineer can decide if the equipment is functioning properly. Revertive call tests should be made on equipment serving multiparty subscribers.

6.4 While it may be desirable to make detailed measurements on station carrier, experience generally has shown that it is not warranted. The operational tests are effective for locating malfunctioning equipment. If there is any question on the quality of the equipment or for large scale installations of station carrier, the telephone company and

engineer may wish to make measurements on a sampling basis. On a voice frequency basis the sampling measurements might include 1000 hertz net loss, frequency response and idle channel noise in each direction of transmission. Refer to TE&CM Section 925, "Transmission Measurements Involving Carrier Multiplex Equipment," for methods of making measurements. On a carrier frequency basis transmit and receive levels at the central office are effective in locating marginal equipment. (Note: The subscriber terminal must be in an "off-hook" condition to transmit carrier.) If the telephone company has a policy of measuring noise, 1000 hertz net loss, or net loss at several frequencies at the subscriber's residence on all physical circuits, the same tests may also be used for all station carrier circuits. The preinstallation tests ("burn-in" and operational) are very effective in reducing installation problems.

7. PURCHASE CONSIDERATIONS

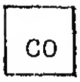
7.1 REA Bulletin 385-2, "Purchasing and Installing Special Electronic Equipment," sets forth methods and procedures for REA borrowers to purchase and install station carrier. This equipment is designed so that it can be easily installed by telephone company personnel without need for detailed application engineering documents. Except as outlined in Bulletin 385-2, small quantities of equipment can be procured as other "shelf items" of equipment such as telephone sets.

7.11 For small quantity purchases, station carrier is procured by the telephone company's normal procedure such as using purchase orders. Funds are advanced from REA upon approval of the installation by the REA Field Engineer through the usual work order procedure in effect.

7.12 For large quantity purchases, it is recommended that informal quotations from several station carrier suppliers be obtained to receive the lowest cost. The equipment should be purchased using standard REA contract forms. REA Bulletin 385-2 mentioned above provides guidance in procedures to follow.

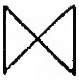
7.2 Appendix II is a checklist to aid in ordering station carrier equipment. This checklist is general in nature because of the variety of station carrier systems currently available. It is intended to offer guidelines on equipment needed and spare parts. An example is included.

The following are symbols used in this section and the meaning of the symbols.



Central office terminal of a station carrier system; includes all channels of a system.

Subscriber terminal of a station carrier system; the number denotes the channel number. Generally used to represent only one channel.


Station carrier repeater.

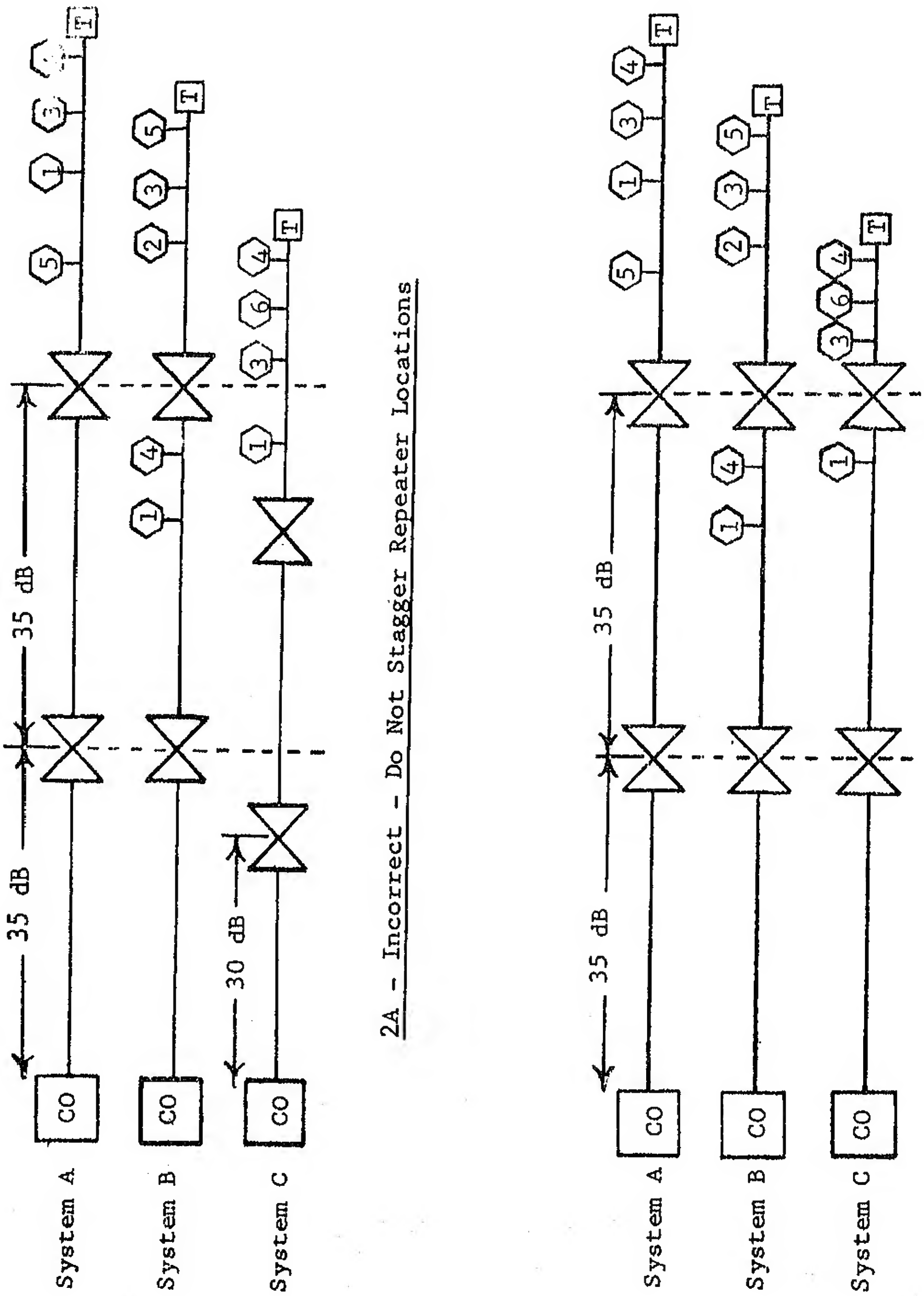
Termination unit; generally a resistor and capacitor. Used at the end of a station carrier system.


Line splitter; generally a carrier frequency hybrid. Used to join carrier frequency bridge taps to the main carrier line.

Low pass filter; used to separate the voice frequency circuit from the carrier frequency circuit.


Subscriber; used to represent each subscriber in the telephone system.

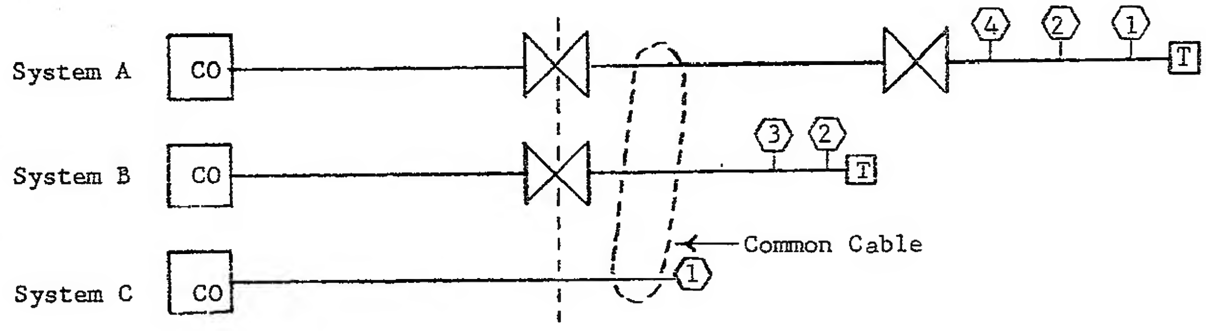
FIGURE 1: SYMBOLS AND THEIR USES



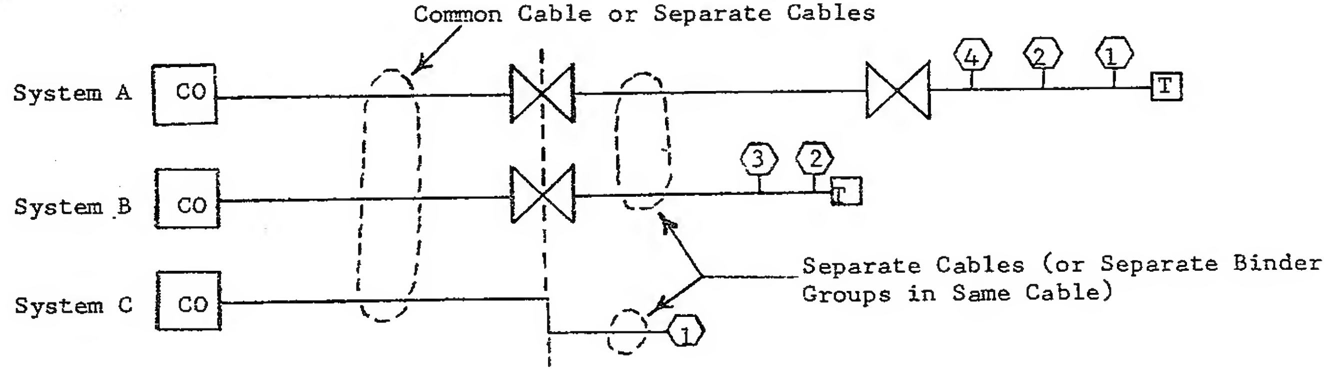
2A - Incorrect - Do Not Stagger Repeater Locations

2B - Correct Repeater Location

FIGURE 2: REPEATER LOCATION



3A - INCORRECT LAYOUT



3B - CORRECT LAYOUT

FIGURE 3: CARRIER LEVEL COORDINATION

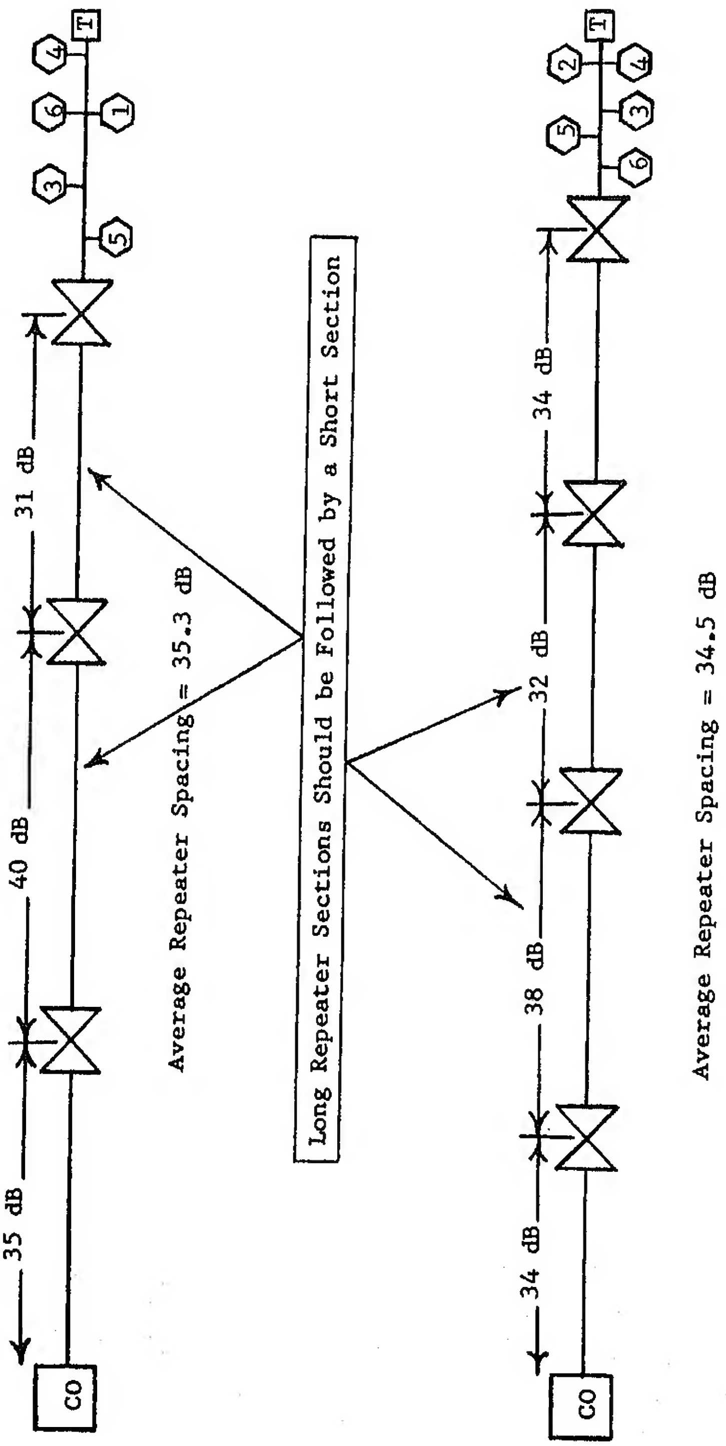


FIGURE 4: REPEATER SPACING SHOULD AVERAGE APPROXIMATELY 35 dB

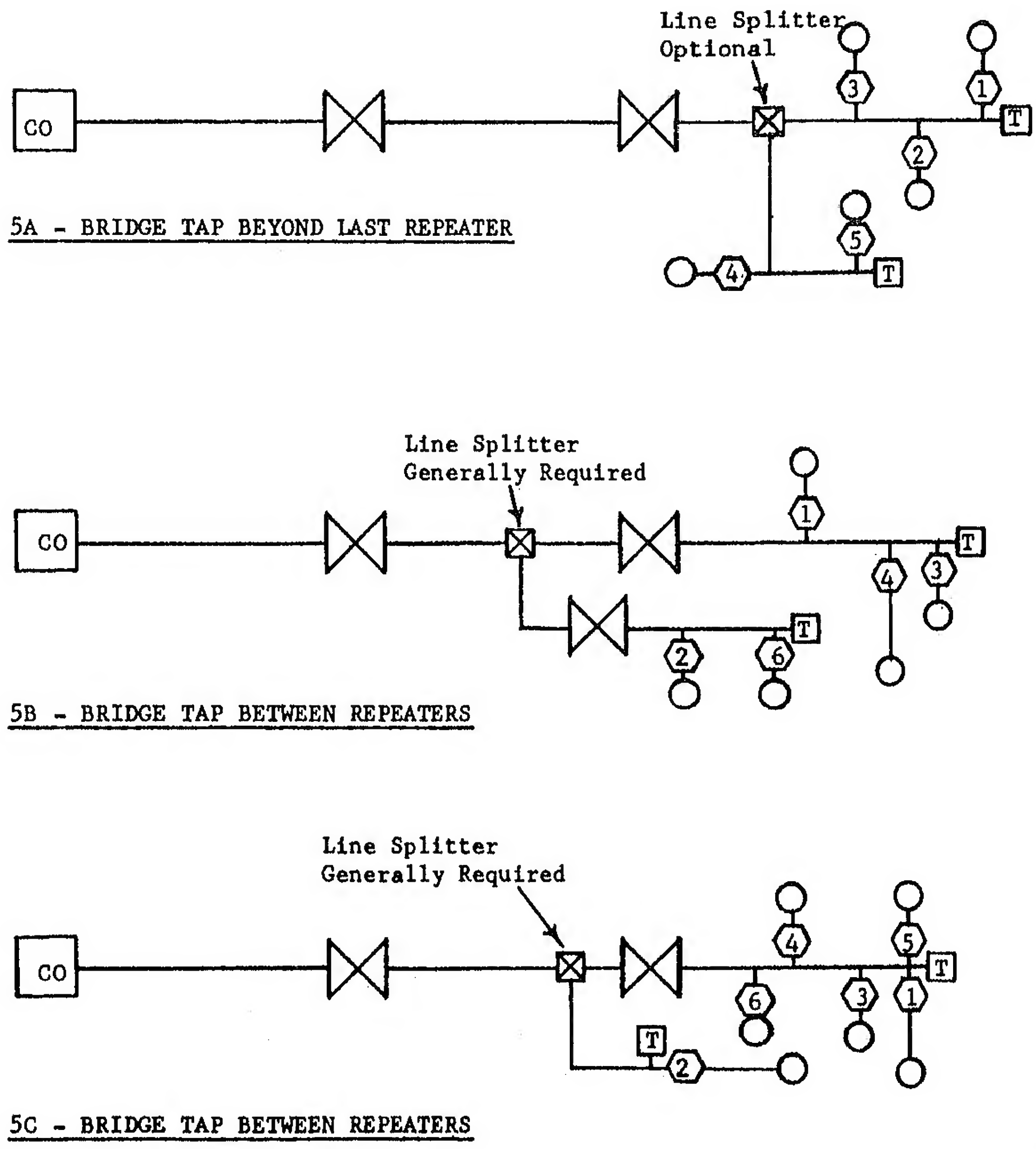


FIGURE 5: CARRIER FREQUENCY BRIDGE TAPS

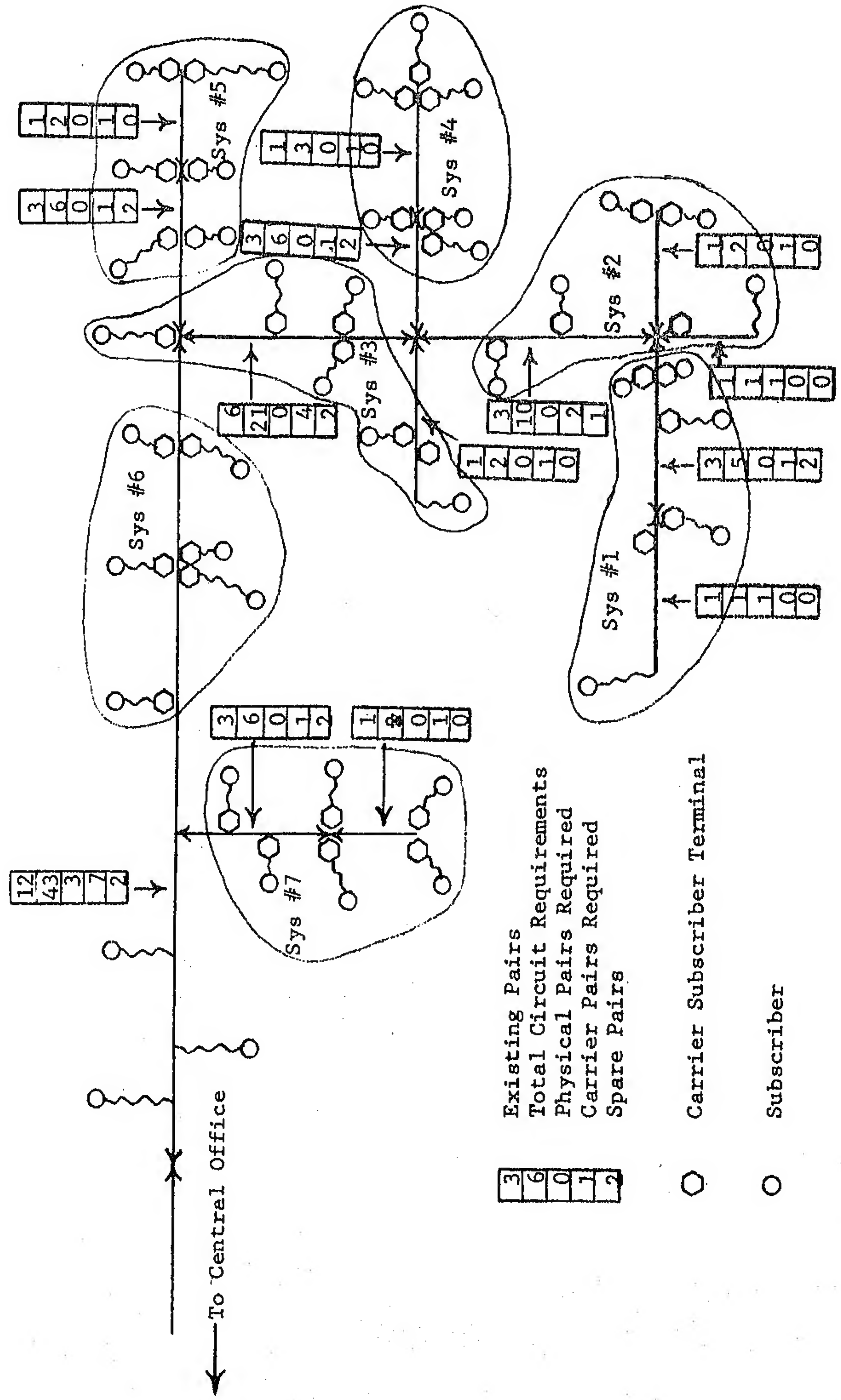


FIGURE 6: EXAMPLE OF CABLE PAIR REQUIREMENTS

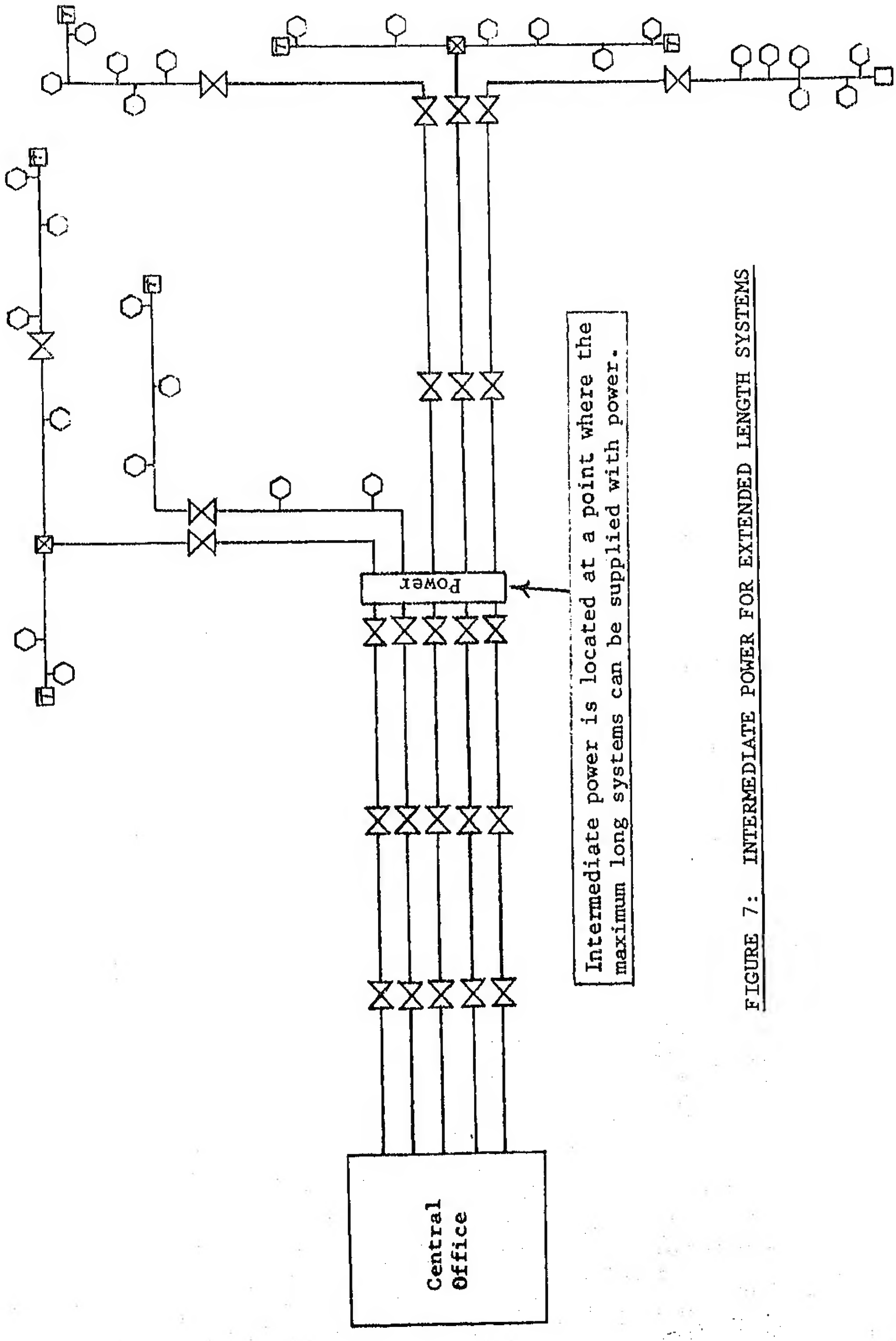


FIGURE 7: INTERMEDIATE POWER FOR EXTENDED LENGTH SYSTEMS

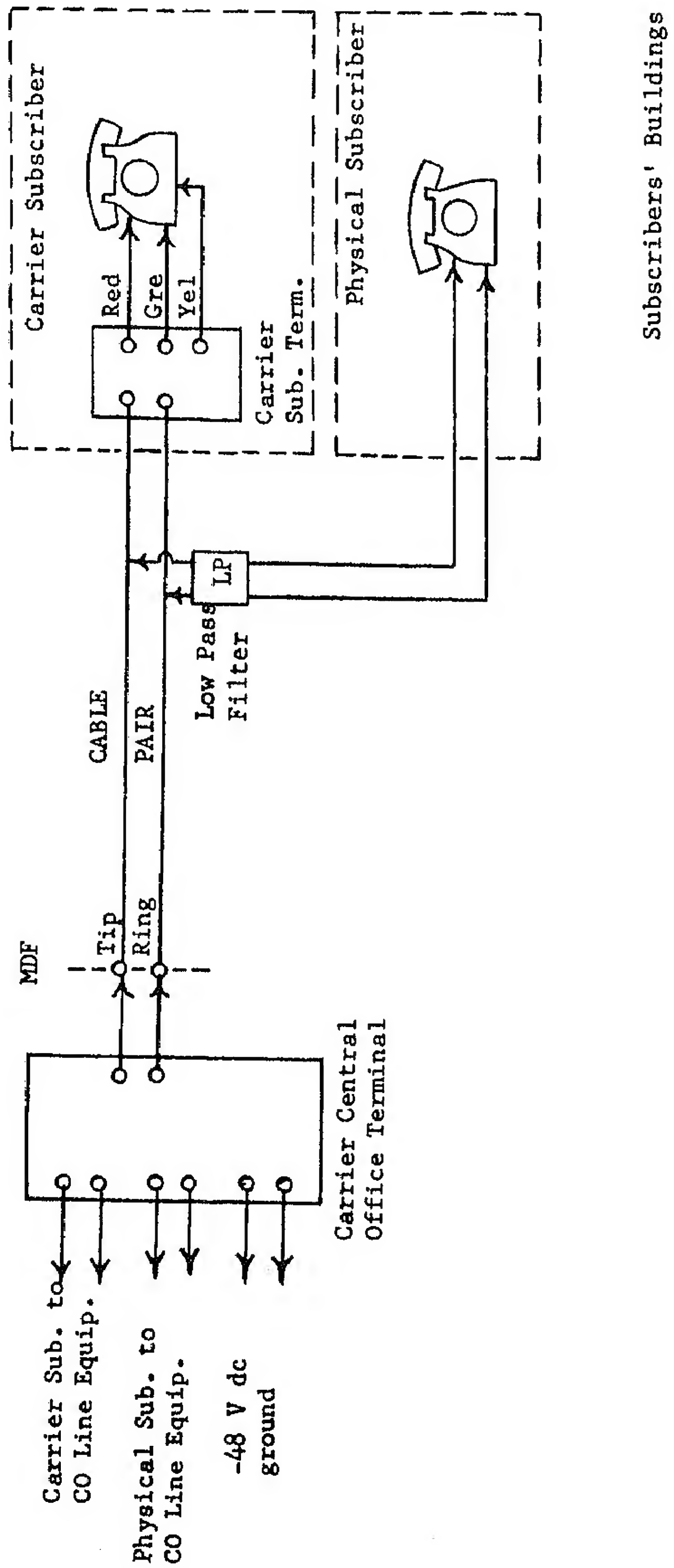


FIGURE 8: SINGLE CHANNEL STATION CARRIER APPLICATION

TABLE 1

112 kHz Attenuation and DC Resistance Data of PIC Cable
(0.083 mFd/Mile)

19 GAUGE			22 GAUGE			24 GAUGE			26 GAUGE		
Length (Miles)	Loss (dB)	Res. (Ohms)	Length (Miles)	Loss (dB)	Res. (Ohms)	Length (Miles)	Loss (dB)	Res. (Ohms)	Length (Miles)	Loss (dB)	Res. (Ohms)
1.0	6.0	85	1.0	9.3	170	0.5	6.8	136	0.5	9.0	216
2.0	12.0	170	2.0	18.6	340	1.0	13.5	271	1.0	17.9	431
3.0	18.0	255	3.0	27.9	510	1.5	20.3	407	1.5	26.9	647
4.0	24.0	340	3.8	35	646	2.0	27.0	542	1.8	35	776
5.8	35	493	4.0	37.2	680	2.5	33.8	678	2.0	39.0	862
6.0	36.0	510	5.0	46.5	850	2.6	35	705	2.5	48.8	1078
7.0	42.0	595	6.0	55.8	1020	3.0	40.5	813	3.0	58.5	1293
8.0	48.0	680	7.0	65.1	1190	3.5	47.3	949	3.5	68.3	1509
9.0	54.0	765	7.5	70	1275	4.0	54.0	1084	3.6	70	1552
10.0	60.0	850	8.0	74.4	1360	4.5	60.8	1220	4.0	78.0	1724
11.7	70	995	9.0	83.7	1530	5.0	67.5	1355	4.5	87.8	1940
12.0	72.0	1020	10.0	93.0	1700	5.2	70	1409	5.0	97.5	2155
14.0	84.0	1190	11.0	102.3	1870	6.0	81.0	1626	5.4	105	2327
16.0	96.0	1360	11.3	105	1921	7.0	94.5	1897	5.5	107.3	2371
17.5	105	1488	12.0	111.6	2040	7.8	105	2114	6.0	117.0	2586*
18.0	108.0	1530	13.0	120.9	2210	8.0	108.0	2168	6.5	126.8	2802*
20.0	120.0	1700	14.0	130.2	2380	9.0	121.5	2439*	7.0	136.5	3017*
22.0	132.0	1870	15.0	139.5	2550*	10.0	135.0	2710*	7.2	140	3103*
23.3	140	1981	15.1	140	2567*	10.4	140	2818*			

Note 1: Data at 68°F; can be used for aerial and buried application.

Note 2: Underlined figures denote repeater spacing intervals for a uniform gauge facility at 35 dB intervals @ 112 kHz.

Note 3: When computing resistance limits, the carrier facility and subscriber drop limits are computed separately.

*Resistance exceeds 2400 ohms; special engineering considerations may be required.

TABLE 2

Wire and Cable Data

Facility	Attenuation at 112 kHz (dB/Mile)	DC Resistance (Ohms/Loop Mile)
16 gauge buried wire, 0.083 uF	3.2	42.4
19 gauge PIC cable, 0.066 uF	4.5	85
19 gauge PIC cable, 0.083 uF[1]	6.0	85
22 gauge PIC cable, 0.083 uF[1]	9.3	170
24 gauge PIC cable, 0.083 uF	13.5	271
26 gauge PIC cable, 0.083 uF	19.5	431
19 gauge paper cable, 0.066 uF	5.3	85
19 gauge paper cable, 0.084 uF	6.8	85
22 gauge paper cable, 0.082 uF	9.8	170
24 gauge paper cable, 0.084 uF	14.5	271
26 gauge paper cable, 0.079	18.4	431
19 gauge RDW (jacketed) wet[2]	6.3	85
22 gauge RDW (jacketed) wet[2]	9.3	170
Open Wire - 1 inch radial ice (estimated)[2]	3.7	-

Note 1: Includes buried wire (shielded).

Note 2: Not generally recommended as a carrier frequency facility.

Note 3: Data at 68°F except open wire attenuation; can be used for aerial and buried application.

APPENDIX I

1. GENERAL

1.1 This appendix will compare the cost of adding cable versus station carrier in two hypothetical examples. For the physical design, the longest loops are within 3000 ohms, using voice frequency repeaters and loop extenders beyond 1700 ohms (outside plant resistance). Example No. 1 is an upgrading to single party and Example No. 2 is an urgent need for several additional circuits. Both physical and carrier designs allow spare pairs (or spare capability) for future growth.

1.2 The cost of cable and electronic equipment will vary from time to time. There is a variation in cost among the various station carrier equipment available today. While some "rules of thumb" might be given to quickly determine whether cable or station carrier is more economical, these costs will not remain constant. Thus, a cost comparison of each route from the central office must be made. The multichannel types of station carrier are primarily considered in these designs but can be complimented by the single channel types within 18 kilofeet. The examples use a 6 channel system at a cost of $500 per channel, repeaters at $350 and single channel types at $170 (installed cost including labor and materials). Annual cost data was computed from the information in TE&CM Section 218 using the installed costs shown in the examples. (Note: Loop extenders are not shown in Section 218; 4 percent depreciation and $5 annual maintenance were used.)

2. EXAMPLE NO. 1

2.1 Exhibits 1 and 2 show one route of an exchange to be upgraded to single party service. By using station carrier the cost of upgrading is $28,400 initial cost and $2,140 annual cost (Exhibit 3). The cost is $86,340 initial cost and $4,759.99 annual cost by adding new cable (Exhibit 4). Either plan allows for future growth and flexibility. The cost of the cable required in the base rate area (physical design) was omitted. The number of pairs required depends largely on the base rate area requirements and this portion generally has little effect on cable versus carrier cost comparisons. CMO and other methods might be compared also.

3. EXAMPLE NO. 2

3.1 Exhibit 5 shows a trailer park requiring 18 new circuits. The cost of distributing the circuits to the trailers and business office from the main cable route will be the same whether carrier or cable is used in the main route. Thus, only the cable versus carrier costs in the main route are considered.

3.2 Exhibit 6 shows that 22 channels of carrier can serve the trailer park plus 4 present subscribers. The carrier can be placed over the 4 pairs that are converted from physical to carrier, leaving the present spares for future use (see Exhibit 5). The cost of this carrier design is $12,400 initial cost and $950 annual cost and service can be provided immediately.

3.3 Exhibit 7 shows the cost to add 37 kilofeet of 18 pair 24 gauge cable plus the associated electronics is $15,544 initial cost and $946.45 annual cost.

3.4 In this example the cost of service is about equal with either cable reinforcement or station carrier, if the cable can be installed immediately. By installing carrier at this time, a more orderly plan of cable reinforcement can be implemented. When the time does come for cable reinforcement, the carrier can be used on another cable route needing relief.

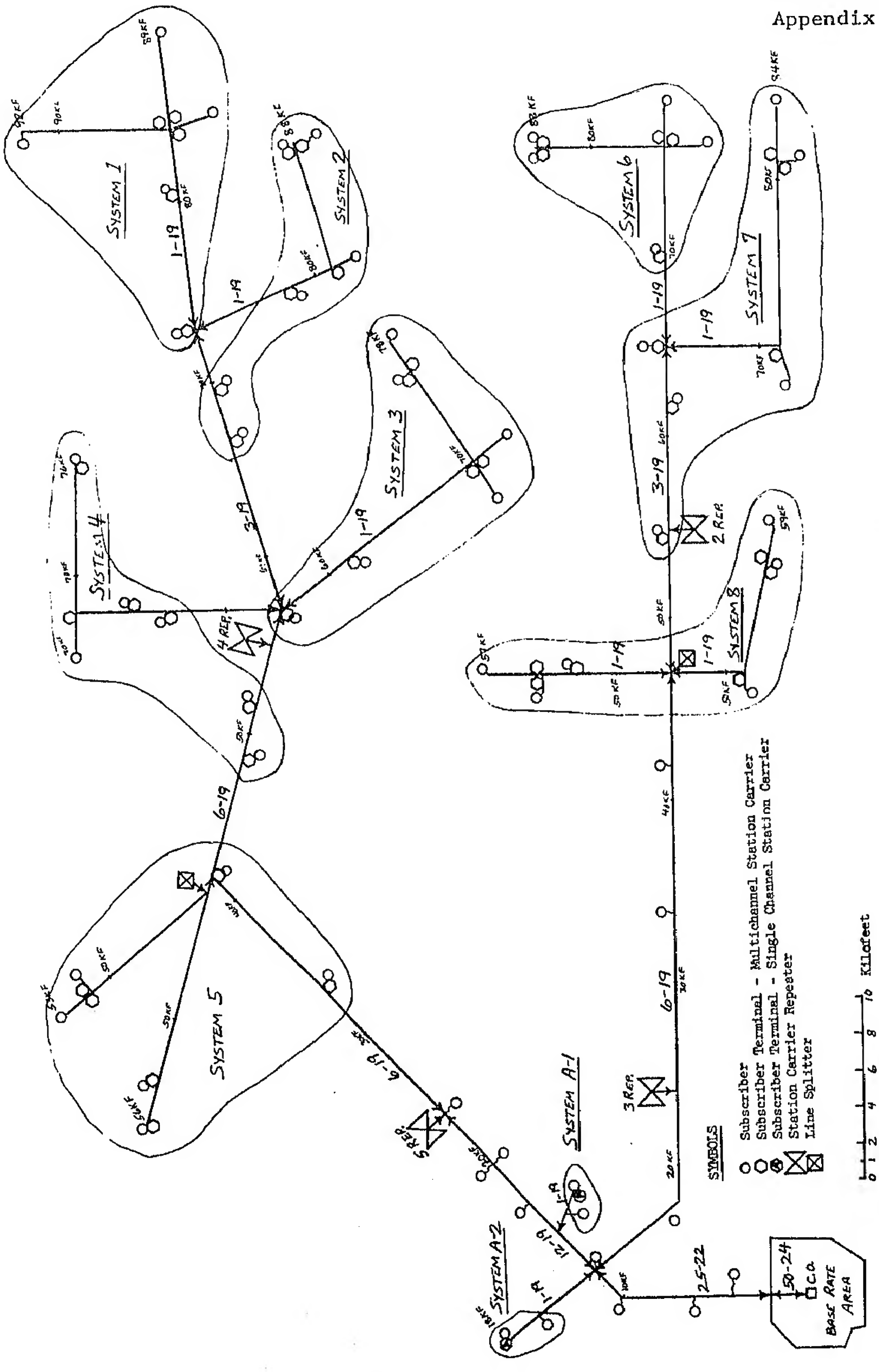


EXHIBIT 1 - Upgrade with Station Carrier

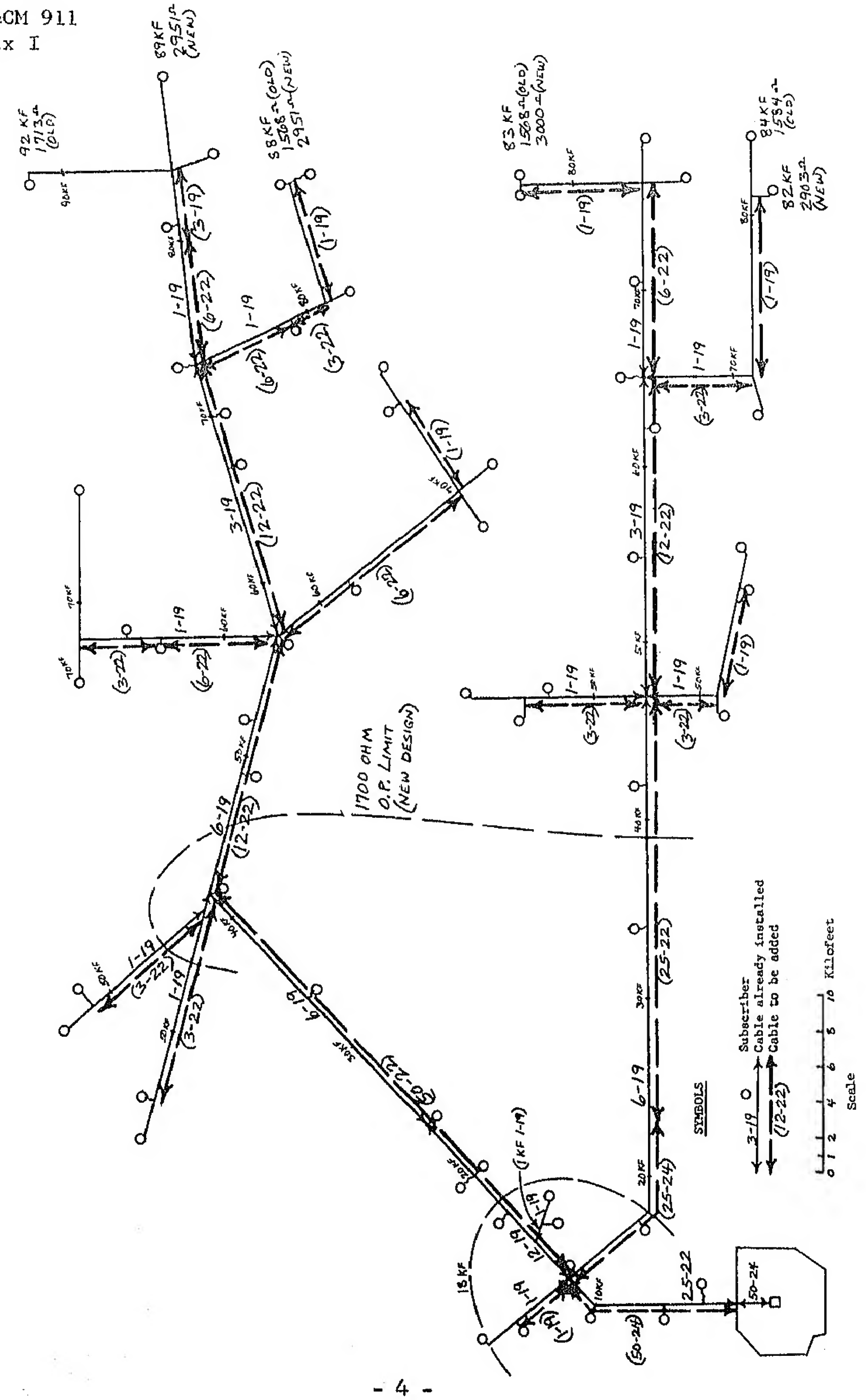


EXHIBIT 2 - Reinforcement with Cable

EXHIBIT 3

Upgrade to Single Party with Station Carrier

Material Required

46 channels (8 systems) of multichannel type of station carrier at $500 per channel installed

14 station carrier repeaters at $350 installed

2 line splitters at $80 installed

2 channels of single channel type of station carrier at $170 installed

No new cable required

Cost of Upgrading with Station Carrier

46 multichannel x $500	=	$23,000	
14 repeaters x $350	=	4,900	
2 splitters x $80	=	160	
2 single channel x $170	=	340	
Total		$28,400	(Initial Cost)

46 multichannel x $40	=	$ 1,840	
14 repeaters x $17.50	=	245	
2 splitters x $4	=	8	
2 single channel x $23.50	=	47	
Total		$ 2,140	(Annual Cost)

EXHIBIT 4

Upgrade to Single Party by Reinforcing Cable Plant

Material Required	Initial Cost	Annual Cost
50 - 24 BJ: 10 KF @	$575 = $ 5,750	10 x $27.13 = $ 271.30
25 - 24 BJ: 11 KF @	$417 = 4,587	11 x $19.86 = 218.46
50 - 22 BJ: 30 KF @	$750 = 22,500	30 x $33.08 = 992.40
25 - 22 BJ: 24 KF @	$466 = 11,184	24 x $21.52 = 516.48
12 - 22 BJ: 49 KF @	$329 = 16,121	49 x $16.87 = 826.63
6 - 22 BW: 43 KF @	$199 = 8,557	43 x $12.79 = 549.97
3 - 22 BW: 43 KF @	$165 = 7,095	43 x $11.09 = 476.87
3 - 19 BW: 4 KF @	$190 = 760	4 x $12.34 = 49.36
1 - 19 BW: 41 KF @	$126 = 5,166	41 x $7.82 = 320.62
33 VFR (at CDO) @	$ 70 = 2,310	33 x $8.50 = 280.50
33 Loop Extenders @	$ 70 = 2,310	33 x $7.80 = 257.40
	Total $86,340	Total $4,759.99

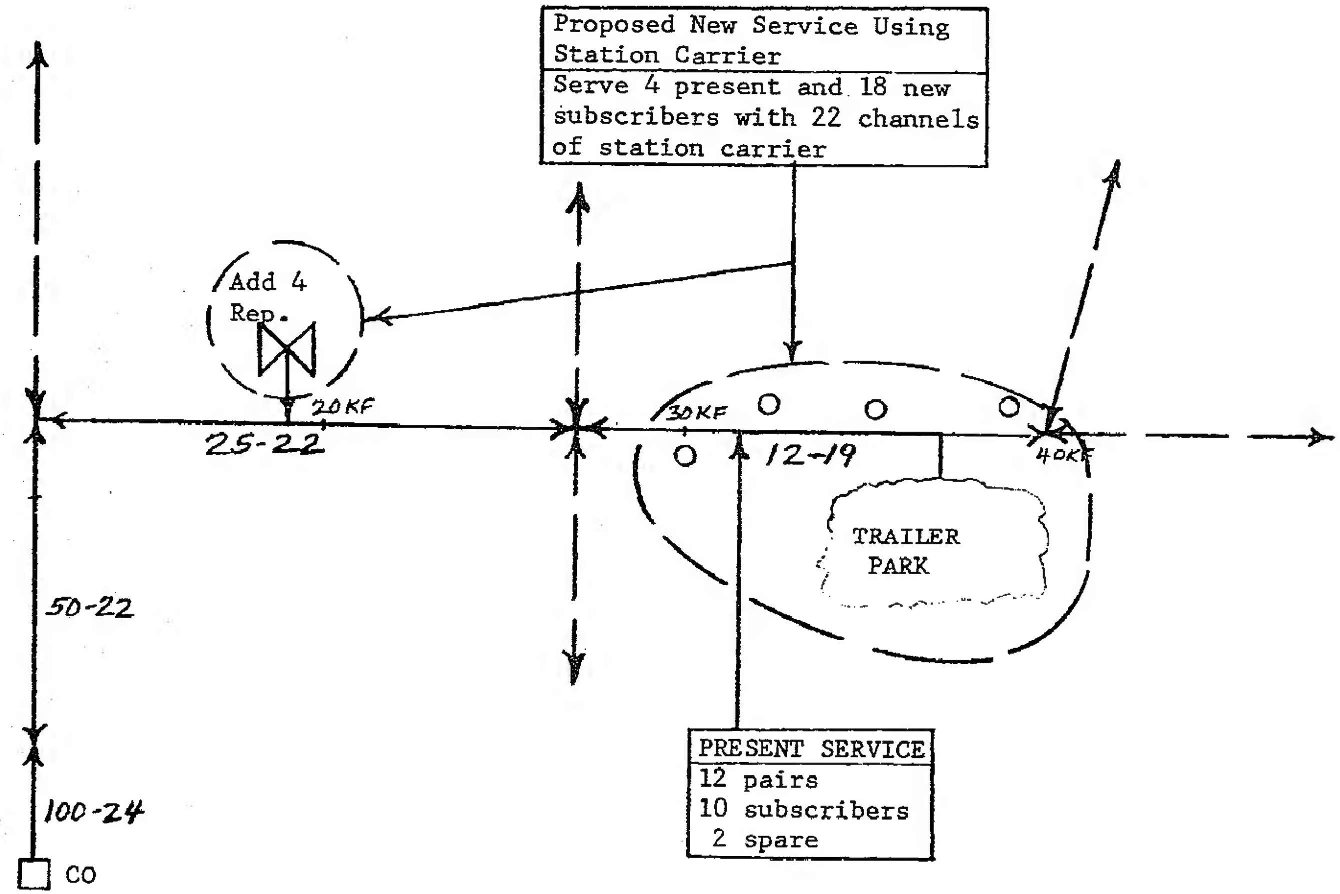


EXHIBIT 5

New Service by Station Carrier or Cable

EXHIBIT 4

Upgrade to Single Party by Reinforcing Cable Plant

Material Required	Initial Cost	Annual Cost
50 - 24 BJ: 10 KF @	$575 = $ 5,750	10 x $27.13 = $ 271.30
25 - 24 BJ: 11 KF @	$417 = 4,587	11 x $19.86 = 218.46
50 - 22 BJ: 30 KF @	$750 = 22,500	30 x $33.08 = 992.40
25 - 22 BJ: 24 KF @	$466 = 11,184	24 x $21.52 = 516.48
12 - 22 BJ: 49 KF @	$329 = 16,121	49 x $16.87 = 826.63
6 - 22 BW: 43 KF @	$199 = 8,557	43 x $12.79 = 549.97
3 - 22 BW: 43 KF @	$165 = 7,095	43 x $11.09 = 476.87
3 - 19 BW: 4 KF @	$190 = 760	4 x $12.34 = 49.36
1 - 19 BW: 41 KF @	$126 = 5,166	41 x $7.82 = 320.62
33 VFR (at CDO) @	$ 70 = 2,310	33 x $8.50 = 280.50
33 Loop Extenders @	$ 70 = 2,310	33 x $7.80 = 257.40
	Total $86,340	Total $4,759.99

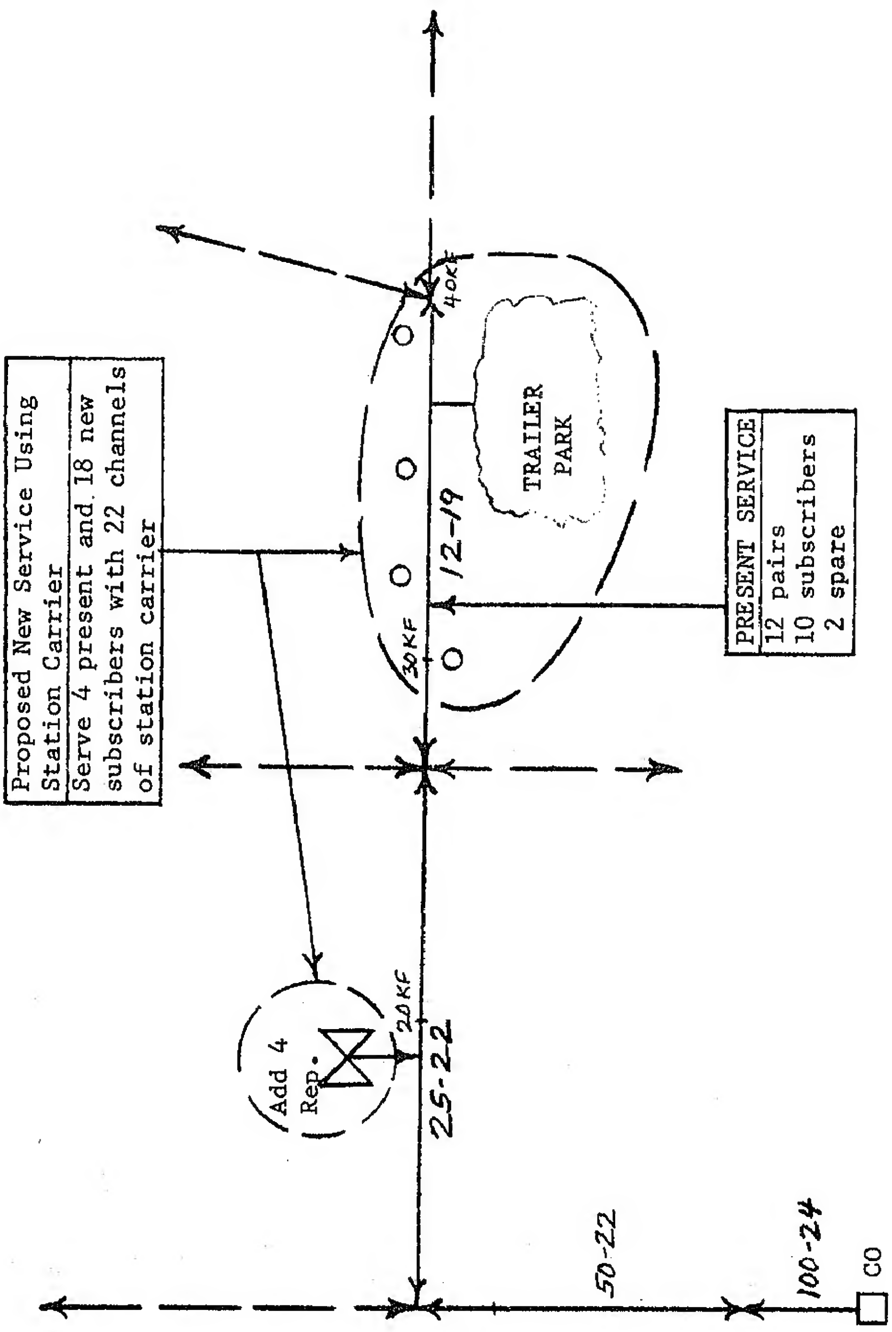


EXHIBIT 5

New Service by Station Carrier or Cable

EXHIBIT 6

Provide New Service with Station Carrier

Carrier Required	Initial Cost		Annual Cost	
22 channels	22 x $500 =	$11,000	22 x $40.00 =	$880
4 repeaters	4 x $350 =	1,400	4 x $17.50 =	70
	Total	$12,400	Total	$950

EXHIBIT 7

Provide New Service with Cable

Material Required	Initial Cost		Annual Cost	
Cable: 42 KF 18-24	37 x $352 =	$13,024	37 x $17.65 =	$653.05
Electronics:				
18 VFR (at CDO)	18 x $70 =	1,260	18 x $8.50 =	153.00
18 loop extenders	18 x $70 =	1,260	18 x $7.80 =	140.40
	Total	$15,544		$946.45

APPENDIX II

EQUIPMENT PURCHASE CONSIDERATIONS

Since there is a variety of station carrier equipment, the following may serve as a general checklist when ordering station carrier equipment.

Standby Equipment

Power supplies or other equipment (such as special ringing systems) that are common to 48 or more channels should be equipped with standby equipment. The standby equipment should be arranged in such a manner that in the event of a failure of primary equipment, the standby equipment will automatically restore operation of systems. Equipment such as power supplies might be arranged in parallel (through diodes) so that service will not be interrupted by the failure of one unit.

Common Equipment

1. Power Supplies

   (a) Most Common: One power supply per system.

   (b) Others: One supply for 2 systems; one supply for 5 systems; one large supply for a large number of systems (standby equipment is recommended for 48 or more channels).

   (c) The above generally refers to supplies powering the repeatered line; power for the central office terminals may be contained in the shelf, on individual channel cards or in the common power supply unit.

2. Ringing Equipment: Only one type of station carrier currently requires special ringing generation equipment. A tone generator is required for each ringing frequency; standby is recommended for 48 or more channels.

3. Other Common Equipment: Some types of equipment have amplifier or common output cards common to one or two systems. Shelves may be common to one or two multichannel systems or as many as 10 or 12 single channel systems.

Central Office Channels

Some equipment offers options. The single party options and bridged frequency ringing are the most popular.

Repeaters

1. Most repeaters are in separate housings; some are arranged for two repeaters per housing.

2. If more than two housing units (repeaters and subscriber terminals) appear at one location, grouping in a common housing is recommended. (This often occurs at the first repeater location.)

Subscriber Terminals

1. Most subscriber channels are in separate housings; some are arranged for two channels per housing.

2. There are some "cluster" arrangements for placing all subscriber channels of a system (or several systems) in a common housing.

3. Single party and bridged frequency ringing are the most popular options. Ringers may have to be changed out to straight line ringers for several types of station carrier.

4. Subscriber drop lengths beyond the subscriber terminal range from 25 ohms of inside wiring for equipment mounted in subscribers' buildings to as much as 300 ohms loop resistance for outside mounted equipment. Compare manufacturers limits to the application engineering information.

5. One type of equipment uses a tone detector and ringing generator inside the subscribers' buildings external to outside mounted channels.

Extended Length Systems

1. Powering extended length systems may be accomplished by raising the voltage level at the central office power supply or supplying intermediate power at a convenient point along the cable route.

2. Special repeaters may be needed for extended length systems.

3. Because of safety, performance and reliability considerations, it is recommended that the manufacturer(s) be given the responsibility for detailed engineering and equipment for extended length systems. The telephone company, consulting engineer and manufacturer(s) should discuss extended length considerations before equipment is purchased and installed.

Miscellaneous

1. Terminations: One carrier line termination is generally required for each system. Each bridge tap must be terminated. This termination is a strapping option in the subscriber channel of one type of equipment. (The inside mounted subscriber terminals of one multichannel system may not follow the above guidelines.)

2. Line Splitters: Line splitters should be ordered according to manufacturers' application instructions.

3. Low Pass Filters: A low pass filter is required for each physical subscriber on the cable pairs with the add-on one channel station carrier systems.

4. Spare Parts: Spare parts should be adequate to avoid lengthy subscriber outage during failures. Spare cards should include several common units and one or more of each channel or noncommon unit. For a small number of systems (i.e., one or two systems), the telephone company might consider retaining one channel of each system as a spare or maintenance channel in lieu of stocking many channel spare parts.

5. Test Equipment: An oscillator, voltmeter and frequency selective voltmeter should be available for maintenance of carrier equipment.

Example

From Example 1 of Appendix I the following equipment might be ordered:

Required:	2	single channel systems
	8	6-channel systems with 46 channels
	14	repeaters
	2	line splitters
		spare parts

Single Channel Systems

1 central office shelf @ $40	=	$ 40
3 CO channels @ $60	=	180
3 subscriber channels @ $70	=	210
3 low pass filters @ $10	=	30
Total		$460

(includes one spare system)

6 Channel Systems

	Common*	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6
System 1	✓	✓	✓	✓	✓	✓	S**
System 2	✓	✓	✓	✓	✓	✓	✓
System 3	✓	✓	✓	✓	✓	✓	✓
System 4	✓	✓	✓	✓	✓	✓	✓
System 5	✓	✓	✓	✓	✓	✓	✓
System 6	✓	✓	✓	✓	✓	✓	S**
System 7	✓	✓	✓	✓	✓	✓	✓
System 8	✓	✓	✓	✓	✓	✓	✓
Total	8	8	8	8	8	8	8

*Common equipment includes shelf, power supply and common card.
**S indicates spare.

8	complete systems @ $2,365	=	$18,920
1	shelf @ $60	=	60
2	power supplies @ $80	=	160
2	common cards @ $60	=	120
1	CO channel 1 @ $120	=	120
1	CO channel 2 @ $120	=	120
1	CO channel 3 @ $120	=	120
1	CO channel 4 @ $120	=	120
1	CO channel 5 @ $120	=	120
1	subscriber channel 1 @ $240	=	240
1	subscriber channel 2 @ $240	=	240
1	subscriber channel 3 @ $240	=	240
1	subscriber channel 4 @ $240	=	240
1	subscriber channel 5 @ $240	=	240
16	repeaters @ $300	=	4,800
3	housings (repeaters) @ $80	=	240
9	termination units @ $5	=	45
2	line splitters @ $75	=	150
	Total		$26,295

This allows a complete spare system to remain in an operating condition in the central office plus an extra set of common equipment spares.